Amendments to the Specification

At page 1, in the title, substitute the amended title:

ON-CHIP MAGNETIC FORCE ACTUATION OF MICROCANTILEVERS BY COPLANAR ~~ON-CHIP~~ COILS

At page 1, first paragraph following "2. Description of the Prior Art" substitute:

Micro- or nanomachined cantilevered beams which have been biofunctionalized are well known as is their proposed use ~~used~~ to detect the presence of bioanalytes by means of changes in the mass of the cantilever and hence its resonant frequency or dynamic performance. However, such bioanalytes are typically carried in a solution which serves to dampen the motion of the cantilever. Thus, one of the challenges has been to obtain a high enough signal from the thermal oscillations of the cantilever or to otherwise effectively drive the cantilever so that its dynamic performance could be usefully utilized to generate an output signal with an acceptable signal-to-noise ratio.

At page 3, first full paragraph, substitute:

The cantilever system further comprises a target spring coupled to the target cantilever about which target spring the target cantilever oscillates and where the transducer comprises a piezoresistive ~~piezoelectric~~ target resistor coupled to the target spring. The piezoresistive ~~piezoelectric~~ target resistor is preferably formed into the target spring. In

the illustrated embodiment the target spring comprises a pair of parallel arms acting as a two-dimensional hinge defining an axis about which the target cantilever oscillates. In this embodiment the piezoresistive ~~piezoelectric~~ target resistor is formed into each arm of the target spring.

At page 3, third paragraph from the bottom of the page, substitute:

The target piezoresistor and dummy piezoresistor are combined in a circuit to form a balancing bridge. The target cantilever and dummy cantilever being fabricated as substantially duplicated ~~duplicate~~ cantilevers.

At page 5, third full paragraph, substitute:

Fig. 4a is a scanning electron micrograph of a nanomagnet array that serves as magnetic actuator component on the cantilever.

At page 8, first full paragraph, substitute:

Fig. 1 is a perspective diagram which illustrates the concept of a magnetic field generated by a planar current line 10. A large drive current 12, symbolically shown in Fig. 1 as an arrow on current line 10, is coupled to a thick gold wire which comprises current line 10 to generate a local magnetic field, which current line 10 in the illustrated embodiment is approximately 600nm thick, and 10μm wide. Field 14 is symbolically depicted in Fig. 1 by field line 14. To efficiently provide a local drive to a

cantilever 18, a 300 nm thick permalloy thin film 16 of size 3μm by 4μm is deposited at the end of the cantilever 18. The gap 20 between the near edge 21 of the current line 10 and permalloy film 16 is about 3μm. The deflection for the cantilever 18 is modeled using the force balance between the force experienced by permalloy film 16 and the resilient restoring force of the cantilever springs 22. Springs 22 are formed by removing a portion 25 from cantilever 18 proximal from film 16. Cantilever 18 is fabricated from a <u>piezoresistive</u> ~~piezoelectric~~ material and deflections of cantilever 18 are measured using a sense current line 27 which is disposed over springs 22.

At page 10, bottom paragraph, substitute:

Fig. 3 <u>shows</u> ~~show~~ a top plan view of the micro-solenoid 50 and the cantilever 18. Figs. 6a – 6i illustrate the fabrication process of three dimensional solenoid 50 with a diagrammatic side cross-sectional view shown on the left and its corresponding top plan view on the right in a pair wise fashion. Fig. 6a shows chip 24 being coated with a Cu or other conductive coating 64, which in the illustrated embodiment is 30nm thick. Thereafter a 1μm insulator layer 66, such as SiN, is disposed on conductive coating 64 as depicted in Fig. 6b. The metal wires fabrication is decomposed into three parts: The bottom conductors 52, the top conductors 58 and the interconnection vias 60. They are all formed by photolithography followed by electroplating. Bottom coils 52 are selectively

electroplated on insulator layer 66 as shown in Fig. 6c. An insulating layer 62 is photolithographically deposited on bottom coils 52 as shown in Fig. 6d, such as deposition of a 1μm layer of photoresist which is then cured, or plasma enhanced chemical vapor deposition (PECVD) of a layer of SiO_2. The lateral ends of bottom coils 52 remain selectively exposed and are not covered by the final configuration of layer 62, leaving the lateral ends available for later electrical connection with vias 60 in Fig. 6g. The magnetic core 54 is first phtolithographically defined and then electroplated in Ni as depicted in Fig. 6e. The tip 56 is patterned by photolithography or by electron beam lithography as best shown in the right portion at the step of Fig. 6e. A second insulating layer 68 is disposed on core 54 at the step of Fig. 6f, again leaving the lateral ends of bottom coil 52 free for later electrical connection. Top coils 58 are then selectively electroplated in Cu or Au onto layer 68 and vertical vias 60 connecting top coils 58 to bottom coils 52 formed across each of the sides of the insulated core sandwich of layers 62, 54, 68 thereby completing the spiral circuit of coils around magnetic core 54 as shown in Fig. 6g. Thereafter, a cap layer 70 of photoresist or SiO_2 is disposed over top coils 58 and layer 68 as seen in Fig. 6h. Further encapsulatization with a metal/SiN heterolayer 72 is then disposed over solenoid 50 as shown in Fig. 6i to provide for electrical shielding and passivation of solenoid 50.

At page 12, last full paragraph, substitute:

Even though difficult to manufacture, solenoid actuator 50 of Fig. 3 has several advantages over the previous two designs. Only bottom conductor lines 52 occupy areas on the surface of the chip 24, so that both the size and stray capacitance can be small; a high concentration of flux can be achieved by merely increasing the number of turns with a relatively small increase in area occupation. A magnetic core 54 made of high susceptibility soft ~~of~~ magnetic material can be implemented to enhance the magnetic field in the coil 50. The magnetic coil 50 can be extended to the proximity of the cantilever magnet 16 without losing magnetic flux inside the core 54, while the solenoid 50 can be placed further away from the cantilever 18. Most importantly, the end of the magnetic core 54 can be made into a flux concentrator shape or a tip 56 to focus the magnetic field. At the end of this tip 56, the magnetic field gradient is enhanced by several magnitudes.

At page 13, bottom paragraph, substitute:

On the other hand, a large force can be simply obtained by increasing the volume of the magnet 16 on the cantilever 18 while maintaining some aspect ratio. Fig. 5f is a microphotograph which shows an electroplated magnet 16 with aspect ratio approximately 3~~nm~~ and diameter of approximately 600nm. A diameter of 200nm with aspect ratio of 5 has also been realized. Magnet 16 is deposited at the end of the

cantilever 18 by electroplating Permalloy into an electron beam defined polymethylmethacrylate (PMMA) mold. The fabrication process is diagrammatically depicted in Figs. 5a – 5e. In Fig. 5a, an aluminum seed layer 78 is first deposited by thermal or electron beam evaporation on chip or wafer 24. A very thick PMMA layer 80 (11%, 495K) is then spin coated on the seed layer 78 as shown in Fig. 5a. After electron beam exposure and after development of a high aspect ratio hole 82 is formed in PMMA layer 80 as shown in Fig. 5b. The magnetic material is placed in a permalloy plating solution and a column magnet 16 of NiFe is plated through the PMMA hole 82 as shown in Fig. 5c. PMMA layer 80 is removed in acetone as shown in Fig. 5d. The seed layer 78 is removed by wet or dry etching as shown in Fig. 5e.